IMERG-based improvements to the Indonesian Fire Danger Rating System

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Fire in Indonesia

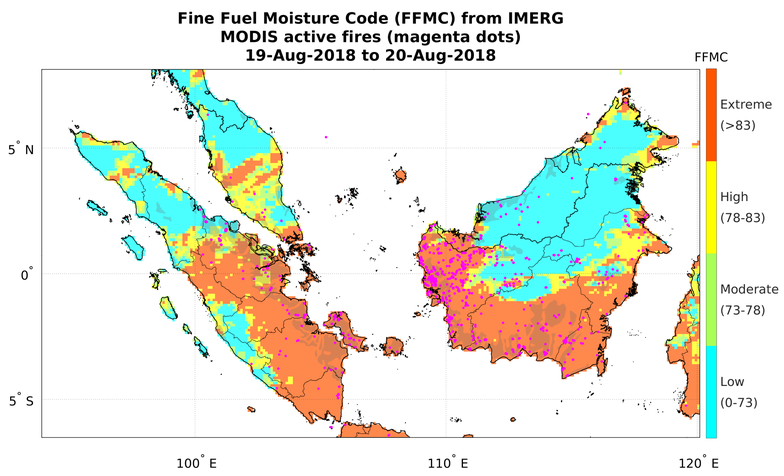
Fire in Indonesia is used to clear and manage land for agriculture and plantation forestry *(1)*. Under sufficiently dry conditions, fires on the surface escape underground into degraded peat, where the fires have an inexhaustible supply of fuel and cannot be extinguished until the return of the monsoon.

During the severe burning of September and October 2015, CO_2-equivalent GHG emissions were 1.5 billion metric tons, between the annual mean fossil fuel emissions of Japan and India (*2,3*). Millions of people were exposed to hazardous air quality for weeks.

Fine Fuel Moisture Code (FFMC)

The Fine Fuel Moisture Code (FFMC) is used in Indonesia as an indicator of the potential for fires to start in light surface fuels, such as tall grass and logging residue *(4)*.

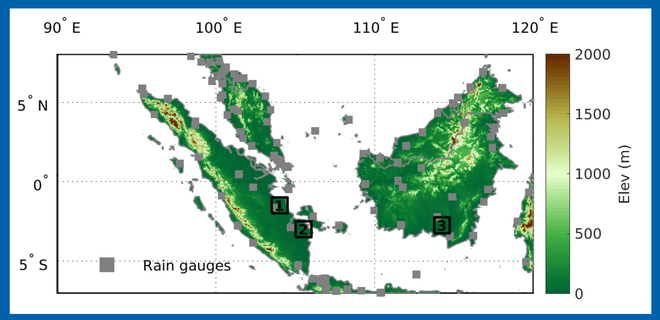
The FFMC ranges from 0-100, with **values greater than 83 considered extreme**. It is calculated from daily 12:00 temperature, relative humidity, wind speed and 24h total precipitation.



This map shows the FFMC calculated using IMERG precipitation and MODIS active fires over August 19-20, 2018. Most active fires are associated with FFMC > 83.

Sensitivity to precipitation estimates

We compared the ability of FFMC calculated from different precipitation estimates to explain 2015-2018 MODIS fire activity for districts in three provinces: 1) Jambi, 2) South Sumatra, and 3) Central Kalimantan. These were regions of especially pronounced fire activity during the 2015 haze disaster *(3)*. The map below shows each region, along with the locations of GTS-level synoptic stations used for operational fire danger rating.



We estimated piecewise linear relationships between the FFMC and fire activity at monthly scales (typical of most fire-climate studies), and down to daily scales, closer to that of fire management decision making, and computed from MERRA2, MERRA2 with rain-gauge correction (MERRA2-C), IMERG-L and IMERG-F *(5)*.

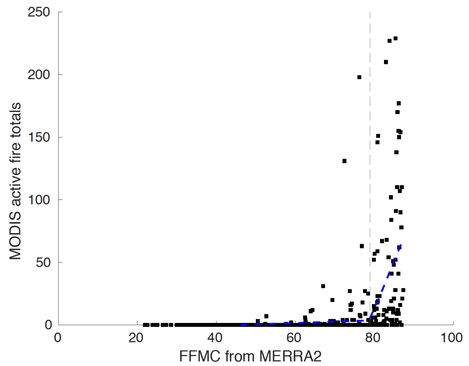
The r^2 values in the table below show that the FFMC explains nearly all (84-100%) of variability in monthly fire activity, but that this decreases for 7-day, 2-day and daily fire totals. In general, FFMC computed from MERRA2 explains the least amount of variation in fire activity, and MERRA2-C and IMERG-f explain the most.

		r^2			
	Precipitation estimate	**1-month**	**7-day**	**2-day**	**1-day**
1. Jambi	MERRA2	0.91	0.56	0.44	0.32
	MERRA2-C	0.96	0.66	0.51	0.37
	IMERG-L	0.84	0.56	0.49	0.32
	IMERG-F	0.95	0.63	0.53	0.36
2. South Sumatra	MERRA2	1.00	0.77	0.74	0.57
	MERRA2-C	1.00	0.82	0.81	0.61
	IMERG-L	1.00	0.84	0.75	0.58
	IMERG-F	1.00	0.94	0.78	0.59
3. Central Kalimantan	MERRA2	0.92	0.76	0.54	0.33
	MERRA2-C	0.96	0.72	0.52	0.32
	IMERG-L	0.96	0.79	0.53	0.35
	IMERG-F	0.98	0.83	0.56	0.36

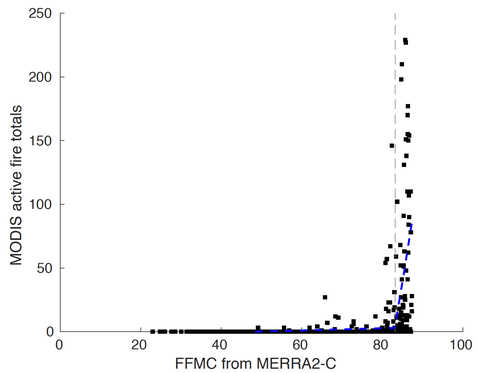
Daily FFMC and fire over Jambi

The scatter plots below show the relationship between daily FFMC and fire activity over region 1), in Jambi province. Despite comparable r^2 values, the FFMC calculated from IMERG-F is better than that computed from MERRA2 or rain gauges in reducing the number of false negatives; that is, days with low FFMC, but high fire activity.

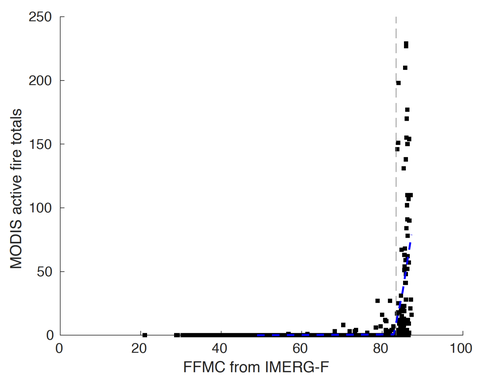
Results were similar for South Sumatra and Central Kalimantan, indicating that **Indonesia's operational use of the FFMC would benefit from the incorporation of GPM-based precipitation estimates**.



For MERRA2, most fire is associated with Extreme FFMC, but with many high-fire days occurring under Low/Moderate FFMC conditions.



Results are better for FFMC calculated from rain gauges, with less fire occurring under Low/Moderate conditions, and with the high fire days occurring under FFMC conditions closer to Extreme.



Results are best for FFMC computed from IMERG-F. There is little fire activity occurring under Low conditions, and all days with extreme (> 50 detections) fire activity occur under 'Extreme' conditions.

References

1. Gaveau DLA, *et al.* (2014) Major atmospheric emissions from peat fires in Southeast Asia during non-drought years: evidence from the 2013 Sumatran fires. *Scientific Reports* 4.

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3. Field RD, *et al.* (2016) Indonesian fire activity and smoke pollution in 2015 show persistent nonlinear sensitivity to El Nino-induced drought. *Proceedings of the National Academy of Sciences of the United States of America* 113(33):9204-9209.

4. de Groot WJ, Field RD, Brady MA, Roswintiarti O, & Mohamad M (2007) Development of the Indonesian and Malaysian Fire Danger Rating Systems. *Mitigation and Adaptation Strategies for Global Change* 12:165-180.

5. Field RD, *et al.* (2015) Development of a Global Fire Weather Database. *Natural Hazards and Earth System Sciences* 15:1407-1423.